

EXAR *DATABOOK*

■ LINEAR ■ CONTROL ■ INTERFACE ■ CUSTOM





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Precision Waveform Generator

GENERAL DESCRIPTION

The XR-8038 is a precision waveform generator IC capable of producing sine, square, triangular, sawtooth and pulse waveforms with a minimum number of external components and adjustments. Its operating frequency can be selected over nine decades of frequency, from 0.001 Hz to 1 MHz by the choice of external R-C components. The frequency of oscillation is highly stable over a wide range of temperature and supply voltage changes. The frequency control, sweep and modulation can be accomplished with an external control voltage, without affecting the quality of the output waveforms. Each of the three basic waveforms, i.e., sine wave, triangle and square wave outputs are available simultaneously, from independent output terminals.

The XR-8038 monolithic waveform generator uses advanced processing technology and Schottky-barrier diodes to enhance its frequency performance. It can be readily interfaced with a monolithic phase-detector circuit, such as the XR-2208, to form stable phase-locked loop circuits.

FEATURES

- Direct Replacement for Intersil 8038
- Low Frequency Drift—50 ppm/°C Max.
- Simultaneous Sine, Triangle and Square-Wave Outputs
- Low Distortion—THD $\approx$ 1%
- High FM and Triangle Linearity
- Wide Frequency Range—0.001 Hz to 1 MHz
- Variable Duty-Cycle—2% to 98%

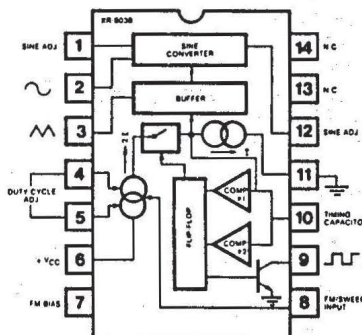
APPLICATIONS

- Precision Waveform Generation Sine, Triangle, Square, Pulse
- Sweep and FM Generation
- Tone Generation
- Instrumentation and Test Equipment Design
- Precision PLL Design

ABSOLUTE MAXIMUM RATINGS

Power Supply	36V
Power Dissipation (package limitation)	
Ceramic package	750 mW
Derate above +25°C	6.0 mW/°C
Plastic package	625 mW
Derate above +25°C	5 mW/°C
Storage Temperature Range	-65°C to +150°C

FUNCTIONAL BLOCK DIAGRAM



ORDERING INFORMATION

Part Number	Package	Operating Temperature
XR-8038M	Ceramic	-55°C to +125°C
XR-8038N	Ceramic	0°C to +70°C
XR-8038P	Plastic	0°C to +70°C
XR-8038CN	Ceramic	0°C to +70°C
XR-8038CP	Plastic	0°C to +70°C

SYSTEM DESCRIPTION

The XR-8038 precision waveform generator produces highly stable and sweepable square, triangle and sine waves across nine frequency decades. The device time base employs resistors and a capacitor for frequency and duty cycle determination. The generator contains dual comparators, a flip-flop driving a switch, current sources, a buffer amplifier and a sine wave converter. Three identical frequency waveforms are simultaneously available. Supply voltage can range from 10V to 30V, or $\pm$ 5V with dual supplies.

Unadjusted sine wave distortion is typically less than 0.7%, with Pin 1 open and 8 k Ω from Pin 12 to Pin 11 ($-V_{EE}$ or ground). Sine wave distortion may be improved by including two 100 k Ω potentiometers between V_{CC} and V_{EE} (or ground), with one wiper connected to Pin 1 and the other connected to Pin 12.

Frequency sweeping or FM is accomplished by applying modulation to Pins 7 and 8 for small deviations, or only to Pin 8 for large shifts. Sweep range typically exceeds 1000:1.

The square wave output is an open collector transistor; output amplitude swing closely approaches the supply voltage. Triangle output amplitude is typically 1/3 of the supply, and sine wave output reaches 0.22 V_s .

XR-8038

ELECTRICAL CHARACTERISTICS

Test Conditions: $V_S = \pm 5V$ to $\pm 15V$, $T_A = 25^\circ C$, $R_L = 1 M\Omega$, $R_A = R_B = 10 k\Omega$, $C_1 = 3300 pF$, S_1 closed, unless otherwise specified. See Test Circuit of Figure 1.

PARAMETERS	XR-8038M/XR-8038			XR-8038C			UNITS	CONDITIONS
	MIN	TYP	MAX	MIN	TYP	MAX		
GENERAL CHARACTERISTICS								
Supply Voltage, V_S							V	$V_S = \pm 10V$. See Note 1.
Single Supply	10		30	10		30	V	
Dual Supplies	± 5		± 15	± 5		± 15	V	
Supply Current		12	15		12	20	mA	
FREQUENCY CHARACTERISTICS (Measured at Pin 9)								
Range of Adjustment								$R_A = R_B = 500\Omega$, $C_1 = 0$, $R_L = 15\text{ k}\Omega$ $R_A = R_B = 1\text{ M}\Omega$, $C_1 = 500\text{ }\mu\text{F}$
Max. Operating Frequency		1			1		MHz	
Lowest Practical Frequency		0.001			0.001		Hz	
Max. FM Sweep Frequency		100			100		kHz	
FM Sweep Range		1000:1			1000:1			S_1 Open. See Notes 2 and 3.
FM Linearity		0.1			0.2		%	
Range of Timing Resistors	0.5		1000	0.5		1000	k Ω	S_1 Open. See Note 3.
Temperature Stability								Values of R_A and R_B
XR-8038M		20	50	—	—	—	ppm/ $^{\circ}\text{C}$	See Note 4.
XR-8038		50	100	—	—	—	ppm/ $^{\circ}\text{C}$	
XR-8038C	—	—	—		50		ppm/ $^{\circ}\text{C}$	
Power Supply Stability		0.05			0.05		%/V	
OUTPUT CHARACTERISTICS								
Square-Wave								Measured at Pin 9. $R_L = 100\text{ k}\Omega$ $I_{\text{sink}} = 2\text{ mA}$ $R_L = 4.7\text{ k}\Omega$ $R_L = 4.7\text{ k}\Omega$
Amplitude	0.9	0.98		0.9	0.98		$\times V_S$	
Saturation Voltage		0.2	0.4		0.2	0.5	V	
Rise Time		100			100		nsec	
Fall Time		40			40		nsec	
Duty Cycle Adj.	2		98	2		98	%	
Triangle/Sawtooth/Ramp								Measured at Pin 3. $R_L = 100\text{ k}\Omega$ $I_{\text{out}} = 5\text{ mA}$
Amplitude	0.3	0.33		0.3	0.33		$\times V_S$	
Linearity		0.05			0.1		%	
Output Impedance		200			200		Ω	
Sine-Wave Amplitude	0.2	0.22		0.2	0.22		$\times V_S$	$R_L = 100\text{ k}\Omega$
Distortion								
Unadjusted		0.7	1.5		0.8	3	%	$R_L = 1\text{ M}\Omega$. See Note 5.
Adjusted		0.5			0.5		%	$R_L = 1\text{ M}\Omega$

Note 1: Currents through R_A and R_B not included.

Note 2: $V_S = 20V$, $f = 10 kHz$, $R_A = R_B = 10k\Omega$.

Note 3: Apply sweep voltage at Pin 8.

$$(2/3 V_S + 2V) \leq V_{sweep} \leq V_S$$

Note 4: $10V \leq V_S \leq 30V$ or $\pm 5V \leq V_S \leq \pm 15V$.

Note 5: 81 k Ω resistor connected between Pins 11 and 12.

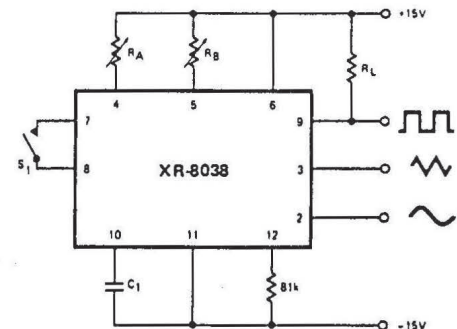
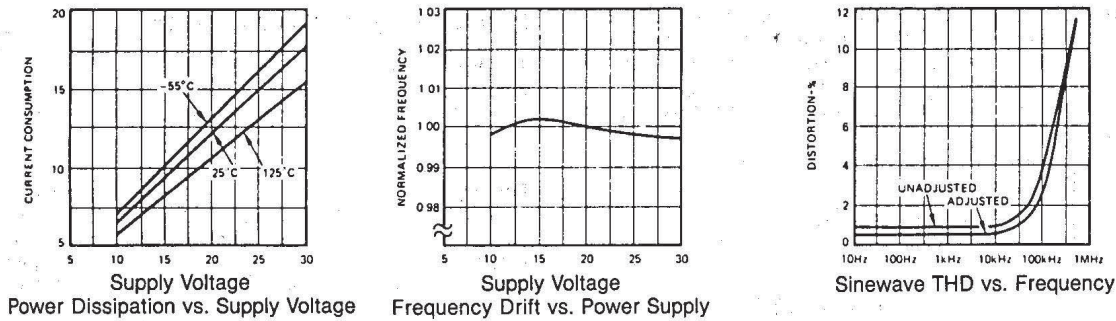


Figure 1. Generalized Test Circuit

XR-8038

CHARACTERISTIC CURVES



WAVEFORM ADJUSTMENT

The *symmetry* of all waveforms can be adjusted with the external timing resistors. Two possible ways to accomplish this are shown in Figure 2. Best results are obtained by keeping the timing resistors R_A and R_B separate (a). R_A controls the rising portion of the triangle and sine-wave and the "Low" state of the square wave.

The magnitude of the triangle waveform is set at $1/3 V_{CC}$; therefore, the duration of the rising portion of the triangle is:

$$t_1 = \frac{C \times V}{I} = \frac{C \times 1/3 \times V_{CC} \times R_A}{1/5 \times V_{CC}} = \frac{5}{3} R_A \times C$$

The duration of the falling portion of the triangle and the sinewave, and the "High" state of the square-wave is:

$$t_2 = \frac{C \times V}{I} = \frac{C \times 1/3 V_{CC}}{\frac{2}{5} \times \frac{V_{CC}}{R_B} - \frac{1}{5} \times \frac{V_{CC}}{R_A}} = \frac{5}{3} \times \frac{R_A R_B C}{2R_A - R_B}$$

Thus a 50% duty cycle is achieved when $R_A = R_B$.

If the duty-cycle is to be varied over a small range about 50% only, the connection shown in Figure 2b is

slightly more convenient. If no adjustment of the duty cycle is desired, terminals 4 and 5 can be shorted together, as shown in Figure 2c. This connection, however, carries an inherently larger variation of the duty-cycle.

With two separate timing resistors, the *frequency* is given by

$$f = \frac{1}{t_1 + t_2} = \frac{1}{\frac{5}{3} R_A C \left(1 + \frac{R_B}{2R_A - R_B} \right)}$$

or, if $R_A = R_B = R$

$$f = 0.3/RC \text{ (for Figure 2a)}$$

If a single timing resistor is used (Figures 2b and c), the frequency is

$$f = 0.15/RC$$

The frequency of oscillation is independent of supply voltage, even though none of the voltages are regulated inside the integrated circuit. This is due to the fact that both currents *and* thresholds are direct, linear function of the supply voltage and thus their effects cancel.

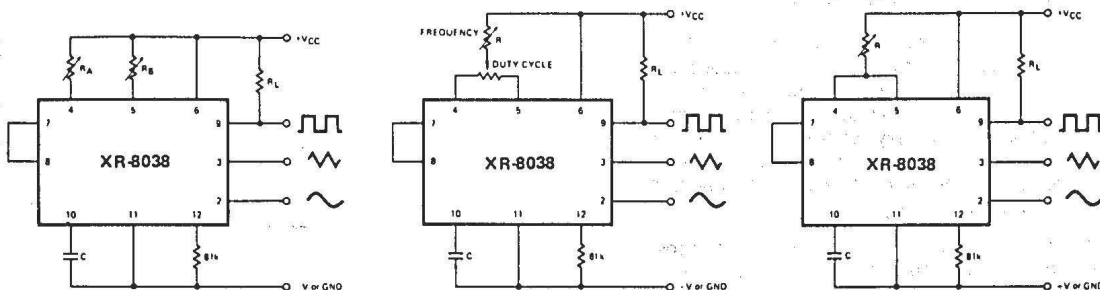


Figure 2. Possible Connections for the External Timing Resistors.

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DISTORTION ADJUSTMENT

To minimize *sine-wave* distortion the 81 k Ω resistor between pins 11 and 12 is best made a variable one. With this arrangement distortion of less than 1% is achievable. To reduce this even further, two potentiometers can be connected as shown in Figure 3. This configuration allows a reduction of sine-wave distortion close to 0.5%.

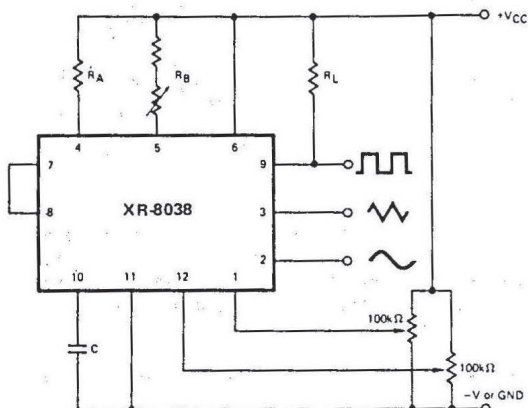


Figure 3. Connection to Achieve Minimum Sine-Wave Distortion.

SELECTING TIMING COMPONENTS

For any given output frequency, there is a wide range of RC combinations that will work. However certain constraints are placed upon the magnitude of the charging current for optimum performance. At the low end, currents of less than 0.1 μ A are undesirable because circuit leakages will contribute significant errors at high temperatures. At higher currents ($I > 5$ mA), transistor betas and saturation voltages will contribute increasingly larger errors. Optimum performance will be obtained for charging currents of 1 μ to 1 mA. If pins 7 and 8 are shorted together the magnitude of the charging current due to R_A can be calculated from:

$$I = \frac{R_1 \times V_{CC}}{(R_1 + R_2)} \times \frac{1}{R_A} = \frac{V_{CC}}{5R_A}$$

A similar calculation holds for R_B .

SINGLE-SUPPLY AND SPLIT-SUPPLY OPERATION

The waveform generator can be operated either from a single power-supply (10 to 30 Volts) or a dual power-supply (± 5 to ± 15 Volts). With a single power-supply the average levels of the triangle and sine-wave are at exactly one-half of the supply voltage, while the square-wave alternates between $+V_{CC}$ and ground. A split power supply has the advantage that all waveforms move symmetrically about ground.

The square-wave output is not committed. A load resistor can be connected to a different power-supply, as long as the applied voltage remains within the breakdown capability of the waveform generator (30V). In this way, the square-wave output will be TTL compatible

(load resistor connected to +5 Volts) while the waveform generator itself is powered from a higher supply voltage.

FREQUENCY MODULATION AND SWEEP

The frequency of the waveform generator is a direct function of the DC voltage at terminal 8 (measured from $+V_{CC}$). By altering this voltage, frequency modulation is performed.

For small deviations (e.g., $\pm 10\%$) the modulating signal can be applied directly to pin 8 by merely providing ac coupling with a capacitor, as shown in Figure 4a. An external resistor between pins 7 and 8 is not necessary, but it can be used to increase input impedance. Without it (i.e. terminals 7 and 8 connected together), the input impedance is 8k Ω ; with it, this impedance increases to $(R + 8k\Omega)$.

For larger FM deviations or for frequency sweeping, the modulating signal is applied between the positive supply voltage and pin 8 (Figure 4b). In this way the entire bias for the current sources is created by the modulating signal and a very large (e.g., 1000:1) sweep range is obtained ($f = 0$ at $V_{sweep} = 0$). Care must be taken, however, to regulate the supply voltage; in this configuration the charge current is no longer a function of the supply voltage (yet the trigger thresholds still are) and thus the frequency becomes dependent on the supply voltage. The potential on Pin 8 may be swept from V_{CC} to $2/3 V_{CC} + 2V$.

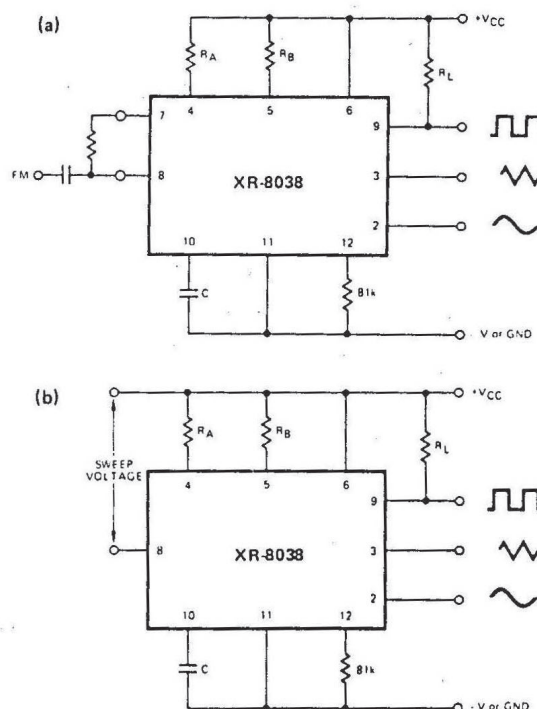


Figure 4. Connections for Frequency Modulation (a) and Sweep (b).